Systematic Status of the Cumberland Island Pocket Gopher, *Geomys cumberlandius*

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ABSTRACT.— The Cumberland Island pocket gopher, *Geomys cumberlandius,* is known only from its type locality on Cumberland Island, Camden County, Georgia. Statistical analyses of 21 morphometric characters of *G. cumberlandius* and 5 mainland populations of *G. pinetis* indicate that coastal populations of *G. pinetis* are more similar to *G. cumberlandius* than they are to more inland populations of *G. pinetis*. These data, coupled with the Recent connection of Cumberland Island to the mainland, argue against taxonomic recognition of *G. cumberlandius*, which is therefore regarded as a synonym of *G. pinetis.*

INTRODUCTION

Until the recent work of Williams and Genoways (1980), *Geomys cumberlandius* Bangs was recognized as one of four nominal species of pocket gophers occurring in Georgia (Hall and Kelson 1959; see also Hall 1981). It has been considered monotypic and known only from its type locality on Cumberland Island, Camden County, Georgia (Fig. 1). *Geomys colonus* Bangs and *Geomys fontanelus* Sherman were also considered monotypic and known only from their type localities in Camden and Chatham counties, Georgia, respectively. *Geomys pinetis* Rafinesque was considered polytypic and widespread throughout Alabama, Florida and Georgia.

Geomys cumberlandius was described in 1898. Specimens were taken on Cumberland Island as late as 1956 but no subsequent specimens were found and the species had been thought extinct. Recently, however, a small population has been reported on the island (H. Neuhauser, pers. comm).

Williams and Genoways (1980) reviewed the systematics of southeastern pocket gophers and concluded, based on morphometrics, that of the four named species only *G. pinetis* is valid. They recognized only two subspecies, *G. p. pinetis* and *G. p. fontanelus*, and synontmized *G. cumberlandius* and *G. colonus* with *G. p. pinetis.*

This manuscript was in preparation when the Williams and Genoways results were published. Because they employed only a portion (77%) of available *G. cumberlandius* specimens, and did not include in their study several characters upon which *cumberlandius* was originally described, an independent corroboration of the systematic status of the species is appropriate. The characters they omitted were: width of nasals, breadth of ascending ramus of maxillary, and measurements of

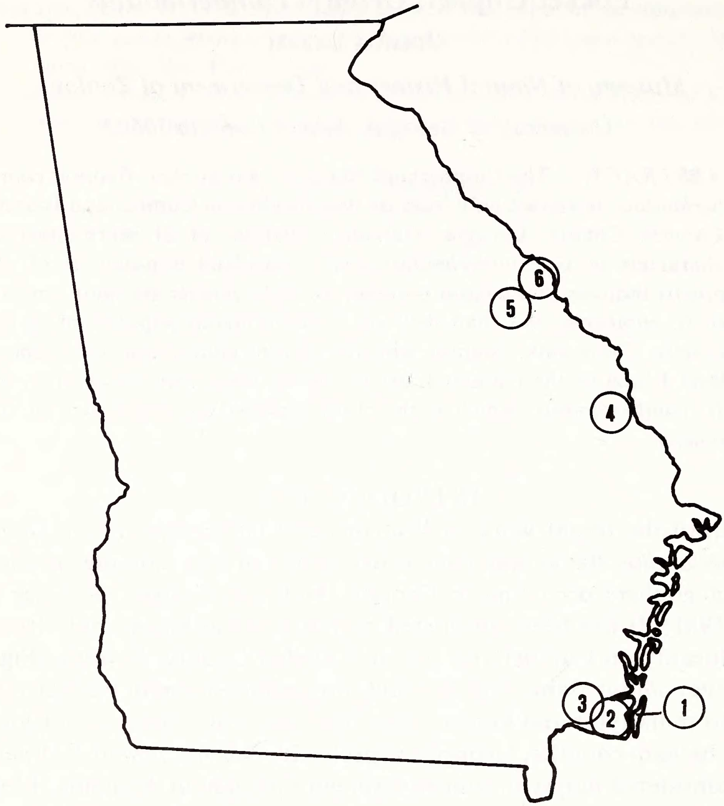

Fig. 1. Location of populations of Georgia pocket gophers examined. 1 = Cumberland Island; 2 = Scotchville, Camden Co.; 3 = Kingsland, Camden Co.; 4 = Hursman's Lake, Screven Co.; 5 = Adam, Richmond Co.; 6= Augusta, Richmond Co.

the auditory bullae. Another reason for corroborating the taxonomic status of *G. cumberlandius* is the current political sensitivity of the Cumberland Island population, which is a possible candidate for state and/or federal endandered status.

MATERIALS AND METHODS

All available specimens of *G. cumberlandius* (N = 73) were examined: Cumberland Island (8, AMNH; 5, CMNH; 1, CU; 13, DMNH; 26, MCZ; 11, NMNH; 9, UGAMNH). These were compared to 157 specimens of mainland *G. pinetis* from the following five populations in east Georgia: Adam (41, MCZ), and Augusta (4, FSM; 11, NMNH), Richmond County; Hursman's Lake (25, MCZ), Screven County; Kingsland (6, FSM; 35, NMNH), and Scotchville (8, AMNH; 10, MCZ; 17, NMNH), Camden County. Acronyms are defined in ACKNOWLEDGMENTS. The Scotchville population, previously recognized as *G.*

colonus has been shown by Laerm et al. (in press) and Williams and Genoways (1980), on the basis of morphometrics, electrophoresis, karyology, and mitochondrial DNA sequence relatedness, to be synonymous with *G. pinetis.* Twenty-one body and cranial measurements were taken to the nearest 0.01 mm with dial calipers. These included: (1) total body length, (2) tail length, (3) hind foot length, (4) condylobasilar length, (5) zygomatic breadth, (6) mastoid breadth, (7) palatal length, (8) palatal depth, (9) rostral breadth, (10) maxillary tooth row length, (11) least interorbital constriction, (12) braincase breadth, (13) nasal length, (14) greatest anterior nasal breadth, (15) breadth of nasals at narrowest point, (16) greatest posterior nasal breadth, (17) interpterygoid fossa length, (18) auditory bulla length, (19) breadth of ascending ramus of maxillary, (20) anterior palatal breadth, and (21) posterior palatal breadth. All measurements except variable 20 were made using the methods of Williams and Genoways (1977) and DeBlase and Martin (1974). Variable 20 was measured across the greatest width of the ascending arm of the maxillary.

It has been well established that body and cranial measurements change during the growth of an individual, but usually not at a constant rate. It is, therefore, frequently desirable to compensate for size variation due to sex and age before comparisons are made. This is particularly true in cases where small sample sizes limit the value of assigning each individual to separate sex and age classes as in the present case. This has commonly been done with proportions or transformation of proportions; however, controversy has recently arisen over the use of these techniques (Atchley et al. 1976; Albrecht 1978; Atchley and Anderson 1978; Dodson 1978; Hill 1978). Fortunately, a number of statistical techniques are available that permit compensation for the effects of size without using proportions. We chose Analysis of Covariance using SAS procedures (Barr et al. 1976) to determine if significant differences could be detected between *G. cumberlandius* and widely separated populations of *G. pinetis.* Males and females were treated separately because of obvious sexual dimorphism. A Multiple Discriminant Function Analysis (SAS) was performed on raw data, separated into male and female groups to obtain generalized distances between populations. These were then clustered by UPGMA (Sokal and Sneath 1973) into distance phenograms to graphically illustrate phenetic distances between populations.

RESULTS

Initial tests of equal slope in the Analysis of Covariance used the following model:

V4 (condylobasilar length)
population
V4 × population.

Results indicate that the interaction term was not significant for the characters examined. Therefore, the intercept (the differences between populations) for the covariate was tested under the following model;

V4
population.

The results of this model (Table 1) indicate significant differences between populations for most characters. For these characters the difference in least squares adjusted means for each population was determined by the Scheffé Test (Morrison 1967) (Table 2).

No significant differences for any of the characters examined can be seen between females of *G. cumberlandius* and other populations of female *G. pinetis.* Males of *G. cumberlandius* can be distinquished from males of other *G. pinetis* populations on the basis of a single character — total length.

Results of the Multiple Discriminant Function Analysis (Fig. 2) similarly indicate low levels of morphological distinction between *G. cumberlandius* and mainland populations of *G. pinetis.* Two assemblages are indicated in both males and females: an upland assemblage consisting of the populations from Adam, Augusta, and Hursman's Lake, and a coastal assemblage consisting of the two Camden County populations and *G. cumberlandius.* The only inconsistency in clustering in both males and females occurs in the apparent relatedness of the coastal Camden County assemblage. Female *G. cumberlandius* and Kingsland *G. pinetis* appear more closely related than either is to the Scotchville *G. pinetis* population, while males from both Camden County populations appear more closely related to each other than either does to the Cumberland Island population. The important point is, of course, that *G. cumberlandius* appears more closely related to coastal Camden County *G. pinetis* than do these *G. pinetis* to their upland conspecifics.

DISCUSSION

Bangs' (1898) description of the insular *G. cumberlandius* was based on a small series of specimens (N = 13) collected at "Stafford Place." He distinquished it from adjacent mainland Georgia and Florida populations of *G. pinetis* on the basis of the very large size and slight pelage and cranial differences. I find that his pelage and cranial features are generally unsatisfactory to permit the distinction of *G. cumberlandius* from other populations of southeastern pocket gophers. Pelage in the *G. pinetis* complex is extremely variable and tends to be correlated with local soil color (Williams and Genoways 1980; Laerm et al., in press). Hence, it has little value in taxonomy. The results of cranial morphometry reported by Williams and Genoways (1980) and herein indicate that cranial differences between *G. cumberlandius* and mainland populations of *G. pinetis* are not sufficient to warrant species level recognition for *G. cumberlandius.*

Table 1. Results of Analysis of Covariance. V4 = condylobasilar length, loc = population, r^2 = correlation coefficient, N = sample size. Asterisks indicate significant (.05 level) figures, NS = nonsignificant figures. See text for discussion.

Males	V1	V2	V3	V5	V6	V7	V8	V9	V10	V11	V12	V13	V14	V15	V16	V17	V18	V19	V20	V21
V4	*	*	*	*	*	*	*	*	*	NS	*	*	*	NS	NS	*	NS	NS	*	*
loc.	*	*	*	NS	*	*	*	*	*	*	NS	*	*	*	*	*	*	*	*	*
r^2	.814	.500	.518	.776	.803	.986	.885	.851	.585	.276	.320	.755	.707	.700	.715	.553	.597	.837	.597	.462
N	102	100	97	102	102	105	105	105	105	105	104	95	103	105	105	96	85	82	105	105
Females	**V1**	**V2**	**V3**	**V5**	**V6**	**V7**	**V8**	**V9**	**V10**	**V11**	**V12**	**V13**	**V14**	**V15**	**V16**	**V17**	**V18**	**V19**	**V20**	**V21**
V4	*	*	*	*	*	*	*	*	*	NS	*	*	*	NS	*	*	NS	*	*	*
loc.	*	*	NS	NS	NS	NS	*	NS	*	*	*	*	*	*	*	*	*	*	*	*
r^2	.656	.384	.367	.907	.451	.981	.880	.803	.527	.303	.556	.790	.763	.338	.657	.477	.790	.594	.524	.543
N	100	100	95	104	97	97	97	101	101	101	103	92	100	100	99	81	87	81	98	98

Table 2. Intrapopulation variation in adjusted means for characters examined for *G. cumberlandius* (1) and other populations of *G. pinetis* as determined by Sheffé Test. See Figure 1 for location legend. Nonsignificant subsets derived from Scheffé Test are indicated by lines below the locality numbers and ranked adjusted means.

Characters	Males						Females					
	1	3	5	6	2	4	1	6	5	3	4	2
1. Total body length	293.68	283.95	279.94	274.87	272.37	247.11	259.67	252.67	251.66	248.71	248.06	244.02
	1	3	6	5	4	2	1	6	5	4	3	2
2. Tail length	101.31	96.75	93.81	91.79	88.46	88.09	87.06	85.90	83.39	83.07	82.54	76.37

Table 2, Continued.

Characters	Males						Females					
	1	6	3	4	2	5	6	5	3	4	2	1
3. Hind foot length	34.88	34.83	34.50	34.01	33.79	33.54	32.24	31.79	31.78	31.77	31.42	31.36
	2	4	5	6	3	1	4	1	2	5	6	3
5. Zygomatic breadth	31.52	31.31	30.95	30.72	30.65	30.30	27.02	26.89	26.76	26.75	26.71	26.57
	6	5	2	1	4	3	5	6	4	2	1	3
6. Mastoid breadth	26.97	26.54	26.39	26.26	25.98	25.95	24.25	23.88	23.81	23.59	23.58	23.38
	3	4	1	2	5	6	3	4	5	2	1	6
7. Palatal length	34.10	34.09	34.02	34.01	33.84	33.67	29.60	29.57	29.49	29.47	29.45	29.41
	5	6	4	2	1	3	4	5	6	3	2	1
8. Palatal depth	18.37	18.31	18.21	18.09	17.97	17.76	16.75	16.48	16.46	16.41	16.31	16.14
	5	3	1	3	6	4	1	3	2	5	4	6
9. Rostral breadth	11.03	10.99	10.94	11.03	10.76	10.70	9.87	9.78	9.71	9.67	9.65	9.58
	5	3	4	6	1	2	6	4	5	3	1	2
10. Maxillary tooth row length	10.25	10.20	10.13	10.09	9.86	9.80	9.74	9.65	9.61	9.55	9.39	9.15

Table 2, Continued.

Characters	Males						Females					
	1	2	3	5	4	6	2	1	3	4	5	6
11. Interorbital constriction	7.26	7.25	7.04	6.93	6.79	6.78	7.18	7.12	7.08	6.88	6.85	6.52
	4	6	1	5	2	3	4	5	6	1	3	2
12. Braincase breadth	20.65	20.39	20.24	20.08	19.87	19.80	19.64	19.31	19.18	19.08	18.95	18.81
	6	5	2	1	3	4	2	1	6	5	4	3
13. Nasal length	19.94	19.20	19.07	18.95	18.89	18.79	16.47	16.40	16.33	16.21	15.88	15.72
	3	2	1	6	5	4	3	2	1	6	4	5
14. Greatest anterior nasal breadth	5.52	5.33	5.17	5.02	5.00	4.92	4.74	4.59	4.58	4.47	4.42	4.31
	3	6	2	5	1	4	6	3	5	2	4	1
15. Midnasal breadth	2.55	2.54	2.50	2.48	2.43	2.14	2.70	2.64	2.56	2.45	2.42	2.24
	5	6	4	3	1	2	6	5	4	3	1	2
16. Greatest posterior nasal breadth	3.67	3.51	3.27	2.92	2.82	2.69	3.51	3.33	3.19	2.87	2.65	2.60
	1	5	4	6	3	2	1	3	5	4	2	6
17. Interpterygoid fossa length	5.48	5.33	5.29	5.29	5.27	5.12	5.09	4.88	4.85	4.72	4.55	4.54

Table 2, Continued.

Characters	Males						Females					
	3	1	2	5	6	4	3	4	2	1	6	5
18. Auditory bulla length	10.22	10.18	10.12	10.00	9.98	9.97	9.57	9.52	9.48	9.40	9.39	9.36
	1	5	3	2	6	4						
19. Maxillary ramus width	12.41	12.38	12.33	12.27	12.24	12.23	10.53	10.47	10.44	10.39	10.37	10.35
	1	2	6	3	5	4	1	22	3	5	6	4
20. Anterior palatal breadth	2.35	2.34	2.15	2.14	2.09	1.94	2.10	2.06	1.96	1.93	1.82	1.70
	2	3	6	1	5	4	2	6	3	1	4	5
21. Posterior palatal breadth	4.32	4.06	3.97	3.97	3.79	3.75	4.26	3.92	3.90	3.83	3.64	3.59

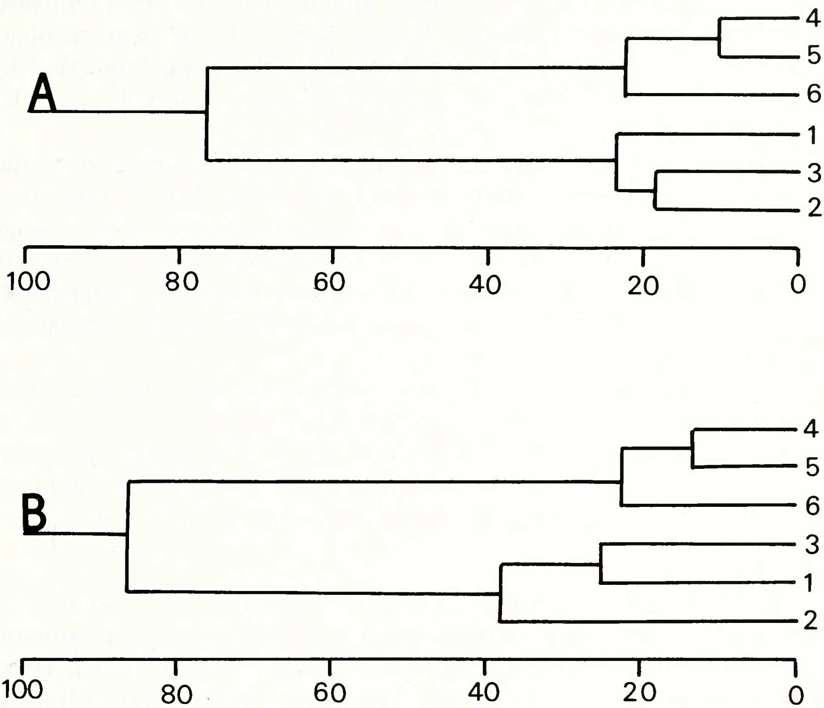

Fig. 2. Distance phenogram for males (A) and females (B). Generalized squared Euclidean distances derived from Discriminant Function Analysis of raw data. Ordinate numbers refer to population locations given in Figure 1; abscissa numbers are generalized squared distances.

The very large size of Cumberland Island gophers in comparison to mainland forms was the chief criterion for Bangs' recognition of *G. cumberlandius.* The data in Table 2 support his observation only in part, because only total length of males is seen to differ significantly in comparison to other populations. However, significant size difference between mainland and insular populations of the same species is not an uncommon phenomenon in vertebrates, particularly mammals (see Case 1978; Heaney 1978). While insular populations of rodents and other small mammals are generally larger than mainland forms, the insular populations are rarely regarded as representing distinct taxa. The large body size of Cumberland Island gophers is consistent with this general observation in other small mammals. Thus, body size alone would not be strong support for species level recognition for Cumberland Island pocket gophers.

Other indirect evidence also argues against such recognition. First, Avise et al. (1979) and Laerm et al. (in press) have shown that populations of pocket gophers throughout eastern Georgia and northeastern Florida show no detectable protein heterozygosity for 25 loci examined, and no karyological differences; based on mitochondrial DNA sequence relatedness, they share a common lineage. Second, based on archaeological evidence it is believed that Cumberland Island was connected to mainland Georgia as recently as 5000-7000 years Before Present (R. Frey, pers. comm.).

Most species and subspecies groups of Recent mammals are, at the youngest, of Pleistocene origin (Hibbard et al. 1965). Russel (1968) suggested that *G. pinetis* differentiated from *Geomys bursarius* by the Sangamon, and *G. pinetis* is recorded from Irvingtonian to Recent deposits in Florida (Webb 1974). Isolation of a population of pocket gophers on Cumberland Island for 5000-7000 years would, in general, be recognized as too short a period for speciation.

I conclude that the most parsimonious interpretation consistent with available data is that *G. cumberlandius* cannot be shown to be distinct from mainland populations of *G. pinetis*. I therefore agree with the conclusions of Williams and Genoways (1980) that pocket gophers on Cumberland Island be synonymized with adjacent mainland *G. pinetis*.

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